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(71) Applicant(s)
Fuji Jukogyo Kabushiki Kaisha

(Incorporated in Japan)

7-2 Nishishinjuku 1-chome, Shinjuku-ku, Tokyo, Japan

(72) Inventor(s)
Toshio Yamaji
Nobumitsu Tanaka

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F02B 31/00 23/00 , F02F 1/42

(52) UK CL (Edition O)
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(56) Documents Cited
EP 0520518 A1 EP 0178663 A2 US 5335634 A

(58) Field of Search
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INT CL^6 F02B 31/00 31/02 31/04 31/06 31/08 , F02F 1/42

(74) Agent and/or Address for Service
W P Thompson & Co
Coopers Building, Church Street, LIVERPOOL, L1 3AB, United Kingdom

(54) I.c. engine charge tumble intake system

(57) The angle θ_1 , fig.2, between the intake port side 41b of the pent-roof of the combustion chamber and the cylinder axis 42 is less than the angle θ_2 between the exhaust port side 41a of the roof and the axis 42, and the intake port 31 has a straight portion 33 the centre-line 35 of which meets the cylinder axis 42 at a near right angle. The radius of curvature of the bent portion 34 of the intake port 31 can thus be made so large as to minimise the pressure drop in the intake port 31. An upstream part of the intake passage 25 is divided by a separator 26 into upper passage 48 and a lower passages 49 which is closable by a flap-type tumble control valve 27. Fuel may be injected by injector 28 downstream of the valve 27 or directly into the cylinder. The combustion chamber roof may be of the multi-hemispherical type.

FIG.1

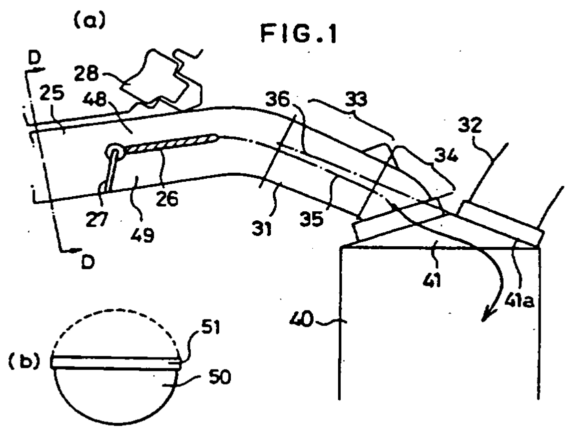

FIG.2

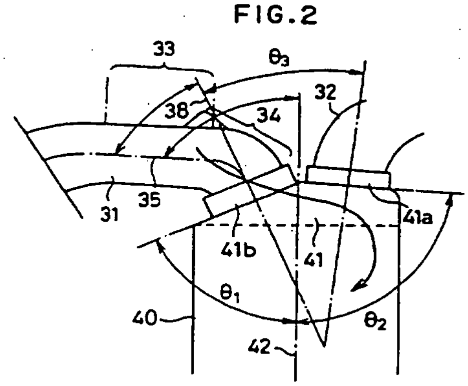

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FIG.1

(a)

(b)

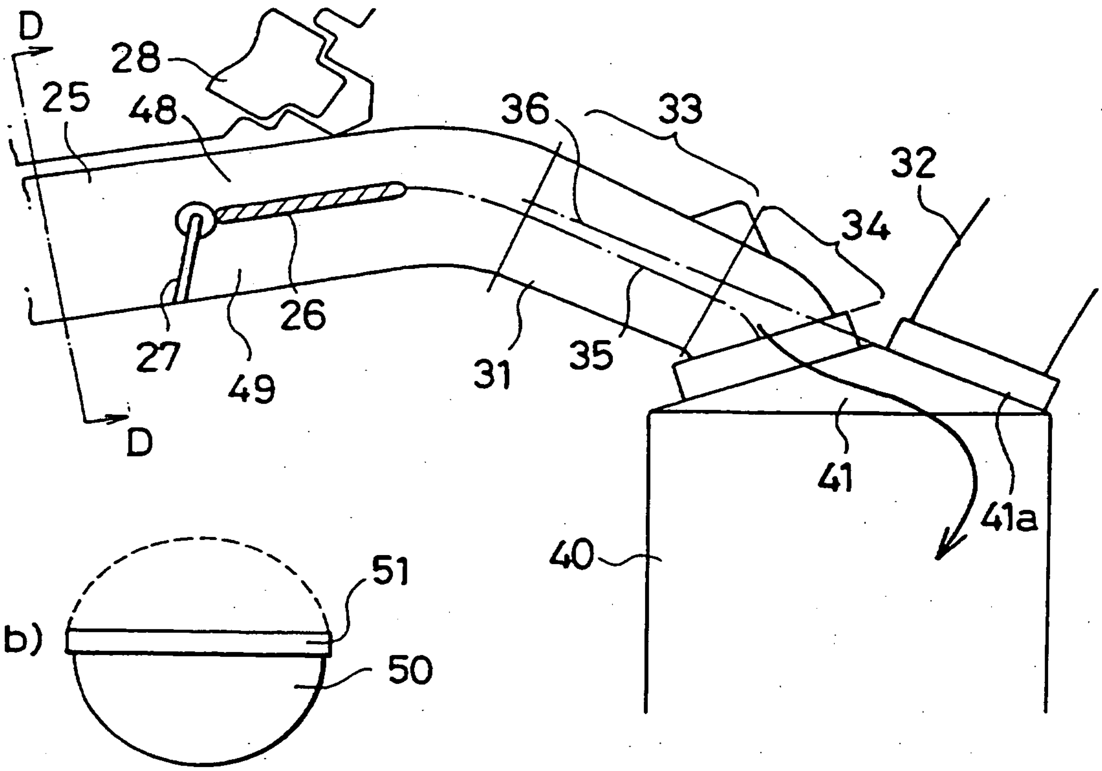

D
28
25
48
36
33
32
34
26
27
49
31
35
D
41
41a
40
51
50

FIG.2

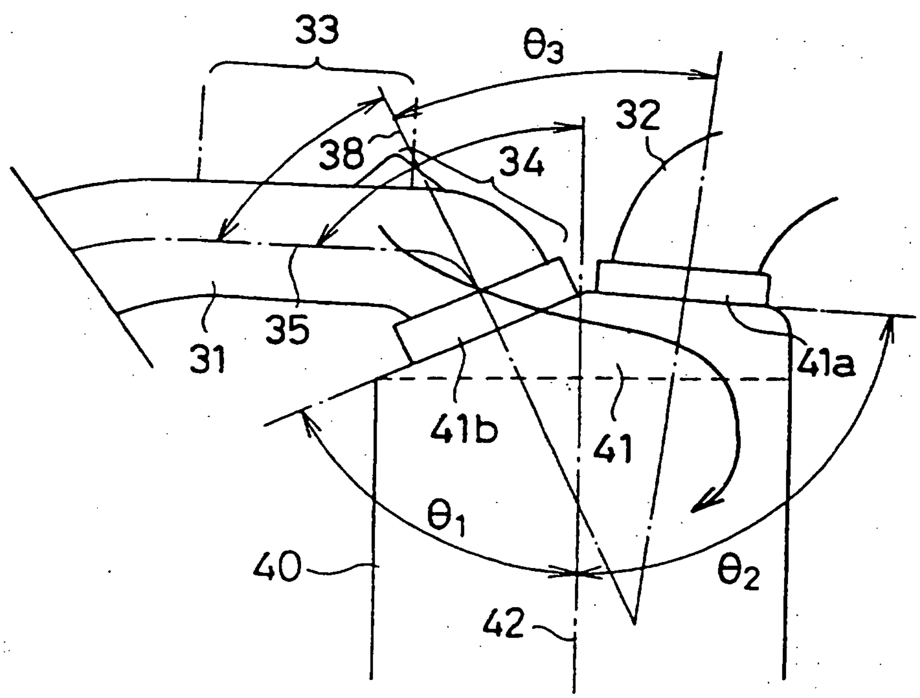

33
θ_3
32
38
34
35
31
41a
41b
41
θ_1
40
θ_2
42

FIG.3

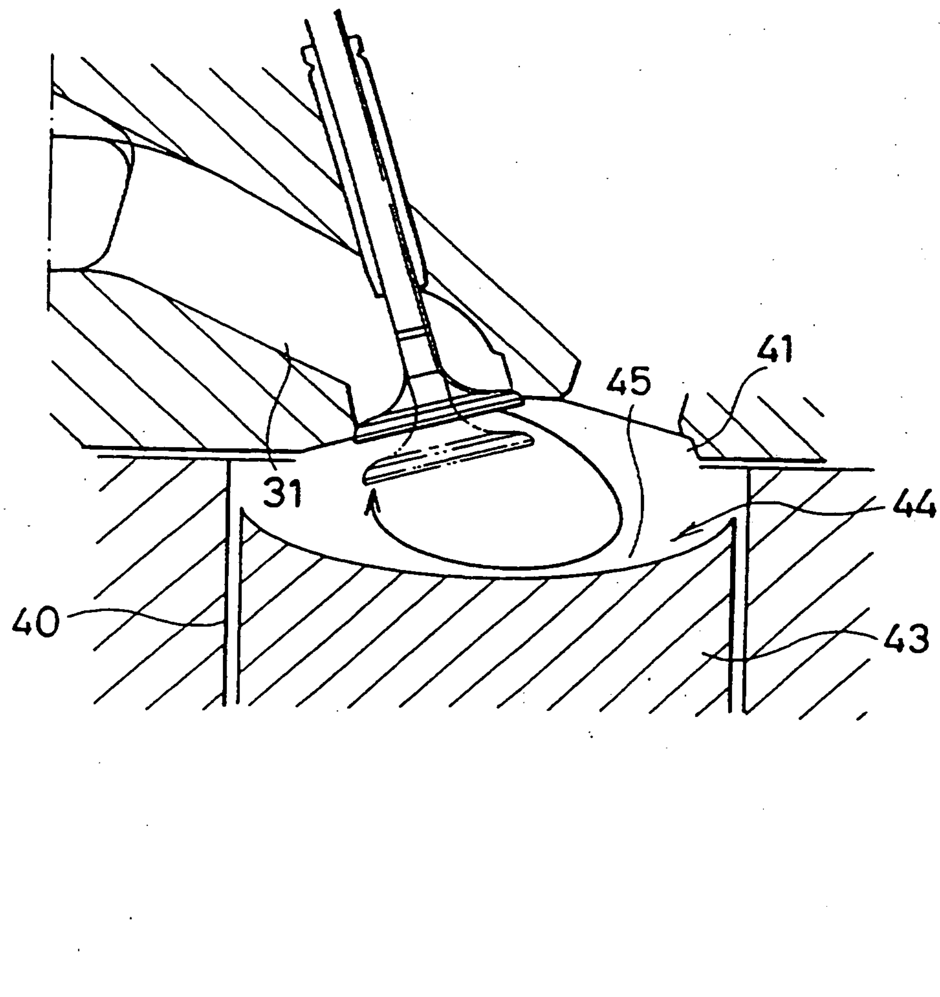
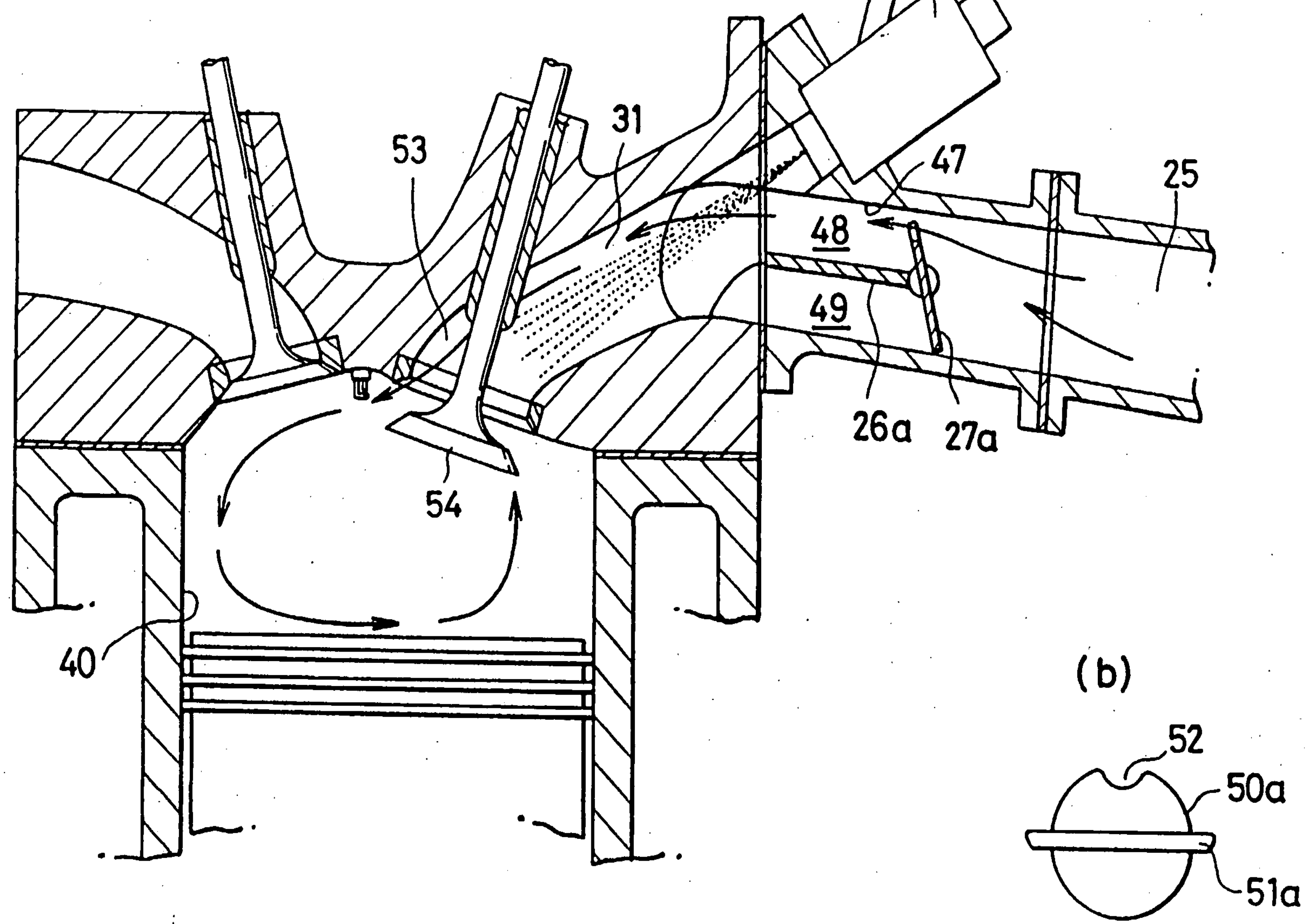


FIG.4

(a)



(b)

FIG.5

(a) (b)

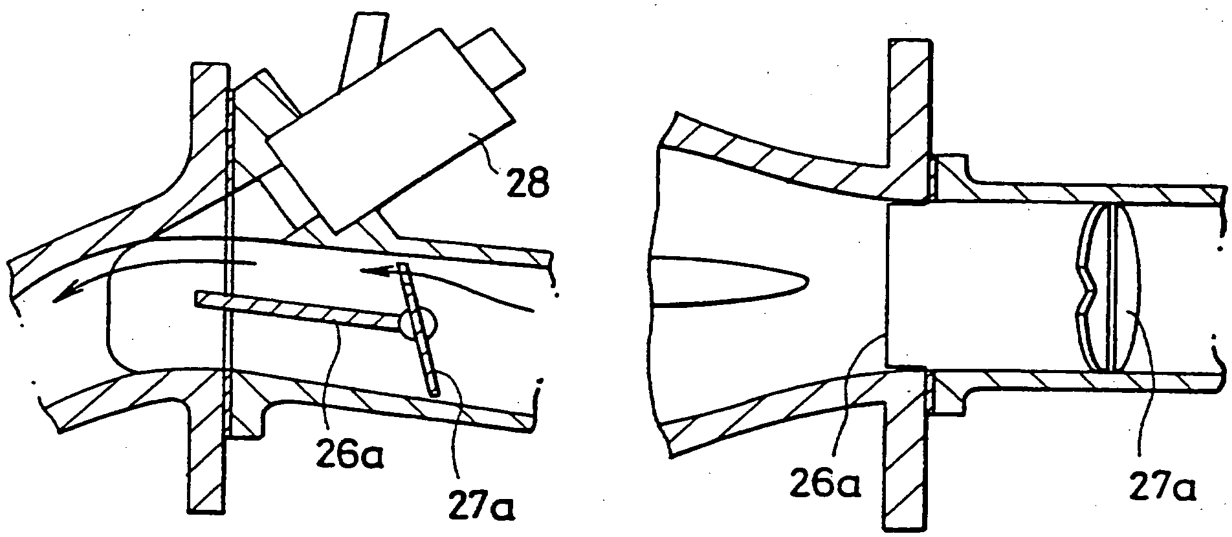


FIG.6

(a) (b)

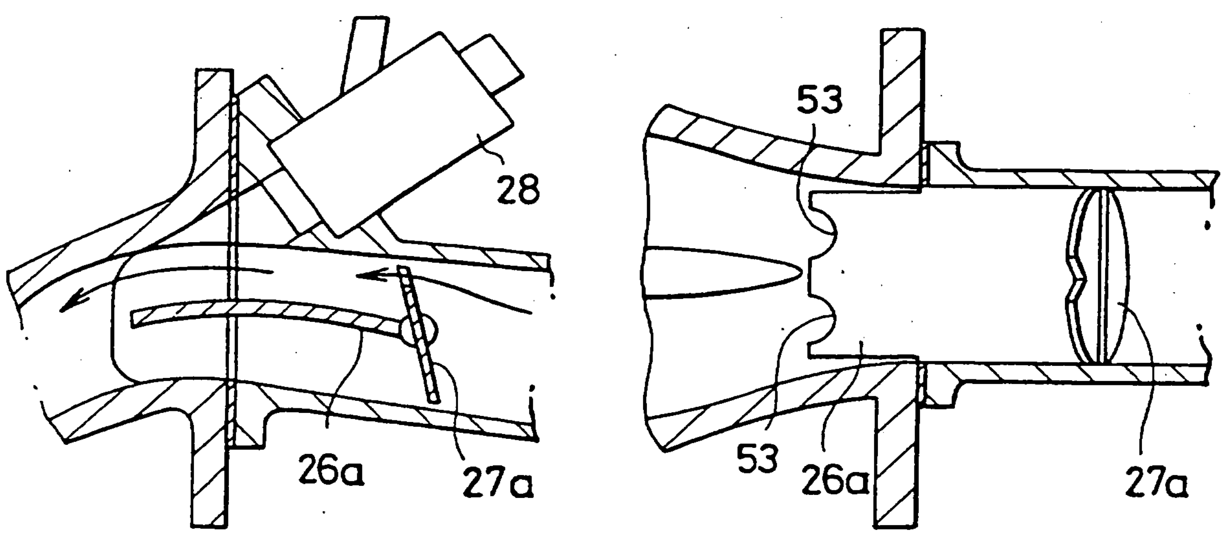


FIG.7

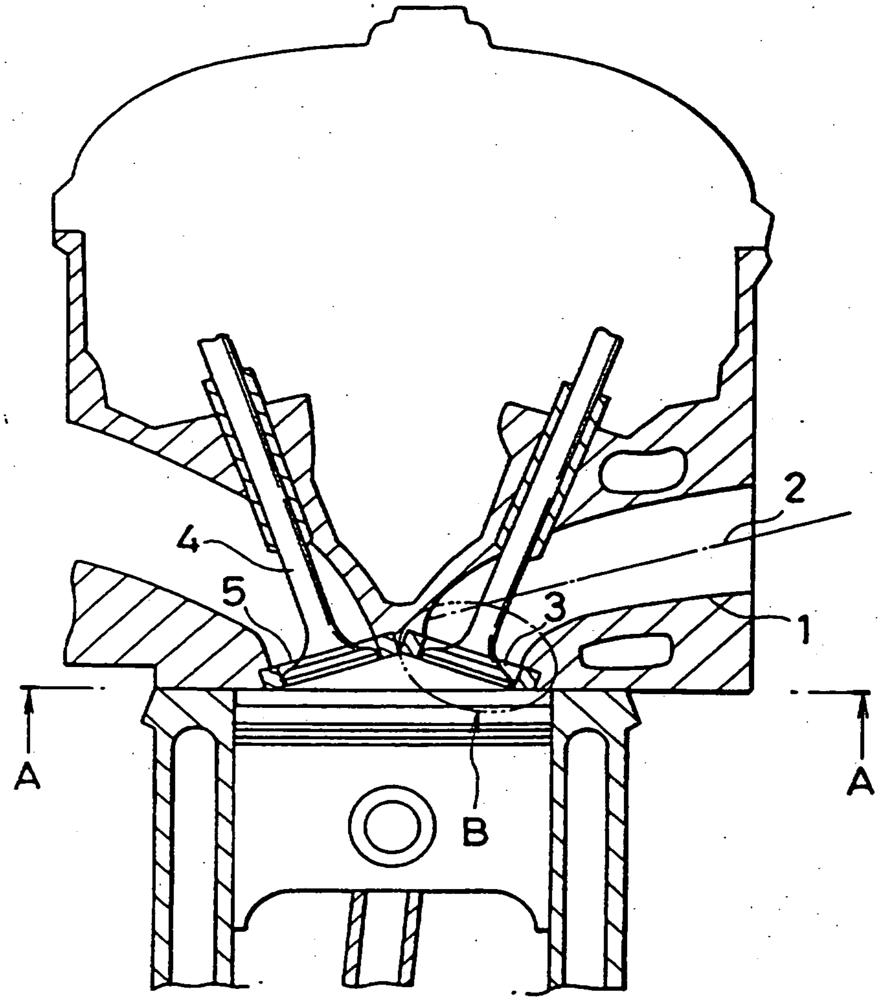


FIG.8

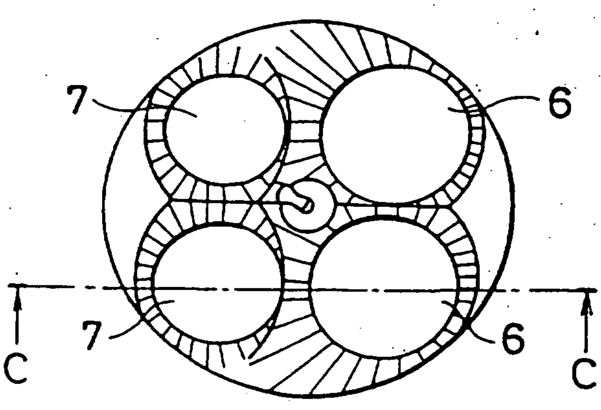


FIG.9

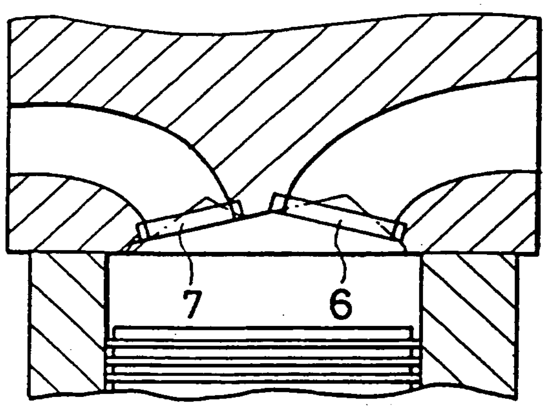
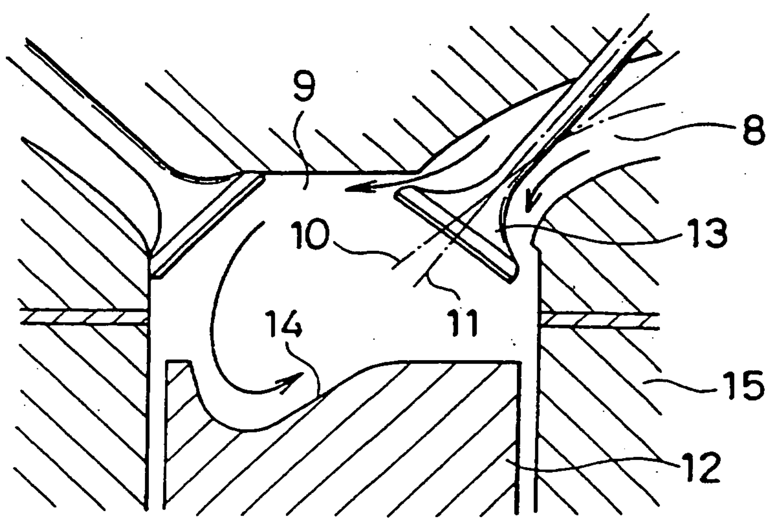


FIG.10



DESCRIPTION

ENGINE AIR INTAKE SYSTEM

The present invention relates to apparatus for improving an engine air intake system and is specifically concerned with an apparatus capable of generating a stronger tumble flow in cylinders by modifying the configuration of the engine air intake port.

This application is divided from application 9420953.3 (GB2283058A), in which an air intake passage has a bent portion connected to the intake port and a straight portion, upstream of the bent portion, parallel with the part of the combustion chamber roof where the exhaust port is situated.

Recently, fuel injection techniques have been dominant in automobile engines since the fuel injection system has a greater possibility of improving fuel economy and exhaust emissions than other fuel systems.

Basically, there are two methods of fuel injection in which one is an intake manifold (intake port) injection method, or a port injection method and the other is a direct injection method. In the intake manifold injection method, fuel is injected under a low pressure into an air intake conduit through a fuel injector disposed at the intake manifold. On the other hand, in the direct injection method fuel is injected under a high pressure directly into a cylinder from a fuel injector disposed in the combustion chamber.

Particularly, in the former intake manifold injec-

tion method, when fuel is injected towards the air flow in the intake manifold, air and fuel are mixed up by the turbulence of the air flow and then the mixture of air and fuel is burned in the cylinder. However, when the engine is operated at light loads, the air flow in the intake manifold is so slow in speed that the injected fuel is burned in an insufficient state of atomization in the cylinder and consequently the combustion efficiency is degraded.

In order to avoid this degraded combustion efficiency at the light loading, there have been disclosed many techniques by which the mixing of air and fuel is performed efficiently by generating a swirl or a tumble in the cylinder.

Here, the swirl abovementioned is an air flow rotating circumferentially along the wall surface of the cylinder and the tumble is an air flow circulating in the direction of the cylinder axis. It is known that the swirl has a large effect on homogenizing the air and fuel mixture but it has little effect on accelerating combustion by the generation of turbulence. On the other hand, it is known that the tumble flow is effective to improve the combustion at the light loading of an engine by a strong turbulence effect which is caused when the tumble is broken near the end of the compression stroke.

As one example of the technology employing this tumble technology, Japanese Utility Application No. Jitsu-

Kai- Hei 3-99833 discloses an intake port as illustrated in Fig. 7.

The intake port is so designed that a straight portion of the conduit is formed upstream of the intake port 1 and a center line 2 of the straight portion abuts on the valve seat 5 of the exhaust valve 4 on the sectional plane containing a center line 2 of the intake port 1.

However, in this construction especially when an angle contained by the intake valve stem and the exhaust valve stem is small, a straight portion of the intake valve sheet or face 3 (portion B enclosed with a circle mark) is inevitably lengthened to avoid a power loss due to a decrease of the effective cross section of the intake port, and thereby it is not possible to obtain an air flow vector able to generate a tumble.

As another example of the tumble technology, Japanese Patent Application No. Toku-Kai-Hei 2-301618 discloses a configuration of the combustion chamber for an internal combustion engine, as illustrated in Fig. 8 and Fig. 9. Namely, the combustion chamber is formed by four conical surfaces and respectively two intake and exhaust valves are provided on each conical surface. Further, in this prior art a ridge line dividing an intake valve side and an exhaust valve side is offset to the exhaust side so as to generate a tumble more easily. In this configuration a "masking effect" tends to occur at the valve seat of the intake valve 6 and

further the combustion tends to become bad due to the large amount of embossing and engraving on the surface of the combustion chamber.

As a further example of the prior art, Japanese Utility Application No. Jitsu-Gan-Sho 61-141457 discloses an induction system for an internal combustion engine as shown in Fig. 10. This prior art proposes a configuration of the combustion chamber 9 in which an intake port 8 is formed in such a way that the center line 10 of the intake port 8 is slanted more to the horizontal direction than the center line 11 of the intake valve stem and further a concave part 14 is provided at the opposite side of the intake valve 13 on the top surface of the piston 12. According to this prior art, the tumble flow is effectively generated by the concave part 14 which is disposed on the opposite side of the intake valve 13. However, since the concave part 14 is offset against the axis of the cylinder 15, the tumble flow can not be kept alive after the bottom dead center of the piston 12.

The aforementioned prior art is concerned with modifications made to the configuration of the combustion chamber or the intake port. However there is one example of the prior art using some additional equipment for generating a tumble. This is a Japanese Patent Application No. Toku-Kai-Sho 58-124019 which discloses a tumble control valve disposed upstream of the intake port in order to generate a deflected stream in the intake port. In that prior art,

however, the deflected stream generated by the tumble control valve is weakened at a relatively early stage of generation, because there is no separate conduit only for letting the deflected stream flow. Therefore, a strong tumble flow can not be expected to be generated in the cylinder.

It is an object of the present invention to provide a configuration of an air intake passage for a fuel injection engine so as to generate a tumble in a cylinder easily. It is another object of the present invention to provide an apparatus for generating a deflected rapid air stream in an air intake passage which thereafter produces a tumble in a cylinder.

In accordance with a first aspect of the present invention, there is provided a fuel injection engine having a combustion chamber with a roof, an intake valve for closing an intake port provided on a first part of said roof of said combustion chamber, an exhaust valve for closing an exhaust port provided on another part of said roof, a cylinder and a piston, the engine comprising:

said combustion chamber including a first angle contained by said roof face on said roof and an axis of said cylinder, and a second angle contained by a roof face of said other roof and said axis of said cylinder, said first angle being substantially smaller than said second angle; and

an air intake passage including a first straight portion and a second straight portion, said first straight portion provided at the upstream part of said air intake passage and a centre line of said first straight portion angled approximately orthogonally with said axis of said

cylinder.

In accordance with a second aspect of the present invention, there is provided a fuel injection engine having a combustion chamber with a roof, an intake valve for closing an intake port provided on a first part of said roof of said combustion chamber, an exhaust valve for closing an exhaust port provided on another part of said roof, a cylinder and a piston, the engine comprising:

said combustion chamber including a first angle contained by a roof face on said first part of said roof and an axis of said cylinder, and a second angle contained by a roof face of said other part of said roof and said axis of said cylinder, said first angle being substantially smaller than said second angle;

an air intake passage including a straight portion provided at the upstream part of said air intake passage and a centre line of said straight portion angled approximately orthogonally with said axis of said cylinder;

a dividing wall provided at an upstream part of said air intake passage for dividing said air intake passage into a first passage and a second passage, said first passage provided further from said cylinder than said second passage; and

a valve for closing said second passage.

By way of example only, specific embodiments of the present invention will now be described with reference to the accompanying drawings, in which:-

Fig. 1 (a) is a schematic drawing showing an air intake system of an engine according to a first embodiment of the present invention.

Fig. 1 (b) is a view of D-D section showing an elevational configuration of a tumble control valve according to the first embodiment of the present invention.

Fig. 2 is a schematic drawing showing an air intake system of an engine according to a second embodiment of the present invention, when a configuration of the combustion chamber of Fig. 1 is changed.

Fig. 3 is a schematic drawing showing an air intake system of an engine according to a third embodiment of the present invention, when a configuration of the piston is changed in Fig. 1.

Fig. 4 is a schematic drawing showing an air intake system of an engine according to a fourth embodiment of the present invention, when a modification has been made to a tumble control valve of Fig. 1.

Fig. 5 (a) is a schematic drawing showing an example of variations of the fourth embodiment.

Fig. 5 (b) is a top view of Fig. 5 (a).

Fig. 6 is a schematic drawing showing another example of variations of the fourth embodiment.

Fig. 6 (b) is a top view of Fig. 6 (a).

Fig. 7 is a sectional view of an intake port according to a prior art.

Fig. 8 is an A-A section view of the combustion chamber according to the prior art in Fig. 7.

Fig. 9 is a partially sectional view of the C-C section in Fig. 8.

Fig. 10 is a sectional view of an engine according to another prior art.

Referring now to Fig. 1 (a), in an intake conduit 25 of an engine intake system there is provided a separator 26 by which intake conduit 25 is separated into upper passage 48 and lower passage 49. Tumble control valve 27 is a valve known as "a flap type" with its hinge 51 connected to the upstream end of separator 26. Further, as shown in Fig. 1 (b), flap 50 of tumble control valve 27 is operated pivotally so as to close or open only lower passage 49.

When the engine is operated at light loads, tumble control valve 27 acts so as to pass intake air with high speed

through upper passage 48 of intake conduit 25 because lower passage 49 is fully closed with flap 50, as shown in Fig. 1 (a).

Here, the term "light loads" or "heavy loads" used in the present invention does not mean the meaning commonly used. For convenience of this invention, the engine operational condition is divided into two conditions, one is "light loads" where the engine is relatively at light loads and another is "heavy loads" where the engine is relatively at heavy loads. Whether the engine is at light loads or heavy loads is determined by referring to a predetermined map parameterizing, for example, an engine speed and a fuel injection amount.

Further, fuel injector 28 is disposed downstream of intake conduit 25 with its nozzle (not shown) oriented toward intake port 31. Intake port 31 is provided downstream of intake conduit 25 and is open to combustion chamber 41 through an intake valve. Also, exhaust port 32 is formed in the vicinity of intake port 31.

In an engine having a pent-roof type combustion chamber, there is a straight portion 33 upstream of intake port 31 and a bent portion 34 immediately following straight portion 33. The configuration of intake port 31 is determined in such a way that the center line 35 of straight portion 33 is approximately parallel with an extended line of roof line 41a of the pent-roof type combustion

chamber 41 on the exhaust port 32 side.

In the engine intake system thus constructed, when the engine is operated at light loads, the intake air flows with high speed through the upper passage of intake conduit 25 by closing the lower passage thereof by means of the rotational operation of tumble control valve 27. Since the intake air flows smoothly along roof line 41a of combustion chamber 41 into cylinder 40, the tumble is efficiently generated therein, whereby combustion is improved at the engine light loads condition.

Fig. 2 is a schematic view showing the intake system according to the second embodiment. In the following description, the same numerals will be used as are used in Fig. 1 and duplicate descriptions will not be made.

As illustrated in Fig. 2, the combustion chamber according to the second embodiment is determined in such a way that an angle θ_2 contained by roof line 41a of combustion chamber 41 on the exhaust port 32 side and an axis 42 of the cylinder 40 is substantially larger than an angle θ_1 contained by roof line 41b of combustion chamber 41 on the intake port 31 side and an axis 42 of the cylinder 40.

In this intake system thus constructed, since a substantially small angle can be taken with respect to the angle θ_1, center line 35 of straight portion 33 of intake port 31 and cylinder axis 42 meet at a near right angle. Consequently, the angle contained by center line 35 of

straight portion 33 of intake port 31 and the intake valve stem becomes obtuse, thereby the radius of curvature at bent portion 34 of intake port 31 can be made so large as to minimize the pressure drop in intake port 31.

This design method according to the second embodiment will be more effective in case where an angle θ_3 contained by the intake valve stem and the exhaust valve stem is rather small.

Fig. 3 is a schematic drawing showing an intake system of an engine according to a third embodiment of the present invention, when a configuration of the piston is modified in the first or second embodiment That is to say, in the third embodiment, bowl 45 is provided on piston head 44 of piston 43 in addition to intake systems according to the first or the second embodiment. Bowl 45 shown in Fig. 3 has a configuration of hemispherical concave so as to let the tumble flow smoothly along the wall of the cylinder and the piston head and to keep that tumble stream without being disturbed for a long time.

Fig. 4 (a) is a schematic drawing showing an intake system of an engine according to a fourth embodiment of the present invention, when a modification has been made to tumble control valve 27 in the first embodiment. In Fig. 4 (a) according to the fourth embodiment, with respect to the separator and the tumble control valve, numerals will be designated hereinafter as 26a and 27a respectively.

The tumble control valve 27a according to this embodiment is a valve known as "butterfly type" with its rotational axis 51 connected to the upstream end of separator 26a. Valve disk 50a of control valve 27a is extended to both upper passage 48 and lower passage 49 and has notch 52 at the edge of valve disk 50a on the upper passage 48 side.

When the engine is operated at light loads where a tumble is needed for combustion improvement, tumble control valve 27a is at a fully closed position as illustrated in Fig 4 (a). With this valve position the intake air flows only into upper passage 48 through an opening formed between notch 52 of tumble control valve 27a and upper wall 47 of induction passage 25. The intake air guided by upper passage 48 grows into a strong deflected stream in intake port 31 and then the fuel is injected into that stream from fuel injector 28. Then air and fuel flow into cylinder 40 in a deflected stream through an upper side 53 of intake valve 54 and consequently the tumble flow is generated in cylinder 40 as shown in Fig. 4 (a). On the other hand, when the engine is operated at heavy loads, since no tumble is needed at these operating conditions, tumble control valve 27a is set at the wide open position where both upper passage 48 and lower passage 49 are fully open.

Fig. 5 and Fig. 6 are drawings showing variations of the fourth embodiment described above. Referring to Fig. 5, separator 26a has been extended as far as possible to the

extent not disturbing fuel injection from fuel injector 28 and in Fig. 6, in addition to the variation above, notch 53 is provided at the downstream end of separator 26a exposed to the injected fuel. These variations are aimed at strengthening the deflected stream for generating a stronger tumble.

In summary, the first embodiment according to the present invention provides an induction system for an engine that can generate a tumble efficiently by means of a tumble control valve and the second embodiment provides an improvement of the first embodiment in which modifications are made to the configuration of the combustion chamber. Further, the third embodiment provides a design of the piston that can maintain the tumble generated by above induction systems as long as possible. Further, the fourth embodiment is an induction system modified in the tumble control valve of the first embodiment.

The combustion chamber described in the preferred embodiments according to the present invention is a pent-roof type combustion chamber. However the aspects of the present invention are also applied to other types of combustion chamber such as multi-hemispherical type.

For example, in case of an engine having a multi-hemispherical type of combustion chamber, with respect to the first embodiment the intake port should be determined in such a way that the center line of the straight portion of the intake port is almost parallel with the valve seatt face of

an exhaust valve. Further, with respect to the second embodiment the roof angles θ_1 and θ_2 should be replaced with the angles contained by the axis of the cylinder and the valve seat faces of the intake and exhaust valves respectively.

Furthermore, in the aforementioned preferred embodiments of the present invention, the fuel system is a so-called port injection type in which the fuel injector is mounted on the intake system, that is to say, fuel is injected before the intake valve. However, the techniques disclosed hereinbefore can be applied to an engine whose fuel system is a so-called direct fuel injection type having an injection nozzle in the combustion chamber.

While the presently preferred embodiments of the present invention has been shown and described, it is to be understood that these disclosures are for the purpose of illustration and that various changes and modifications may be made without departing from the scope of the invention.

CLAIMS

1. A fuel injection engine having a combustion chamber with a roof, an intake valve for closing an intake port provided on a first part of said roof of said combustion chamber, an exhaust valve for closing an exhaust port provided on another part of said roof, a cylinder and a piston, the engine comprising:

said combustion chamber including a first angle contained by said roof face on said roof and an axis of said cylinder, and a second angle contained by a roof face of said other roof and said axis of said cylinder, said first angle being substantially smaller than said second angle; and

an air intake passage including a first straight portion and a second straight portion, said first straight portion provided at the upstream part of said air intake passage and a centre line of said first straight portion angled approximately orthogonally with said axis of said cylinder.

2. The engine according to claim 1, further comprising:

a hemispherical concave provided on the head of said piston whereby tumble flow occurs.

3. A fuel injection engine having a combustion chamber with a roof, an intake valve for closing an intake port provided on a first part of said roof of said combustion chamber, an exhaust valve for closing an exhaust port provided on another part of said roof, a cylinder and a piston, the engine comprising:

said combustion chamber including a first angle

contained by a roof face on said first part of said roof and an axis of said cylinder, and a second angle contained by a roof face of said other part of said roof and said axis of said cylinder, said first angle being substantially smaller than said second angle;

an air intake passage including a straight portion provided at the upstream part of said air intake passage and a centre line of said straight portion angled approximately orthogonally with said axis of said cylinder;

a dividing wall provided at an upstream part of said air intake passage for dividing said air intake passage into a first passage and a second passage, said first passage provided further from said cylinder than said second passage; and

a valve for closing said second passage.

4. An engine as claimed in claim 3, wherein;

said valve is a butterfly valve pivotally connected to an upstream end of said dividing wall and said butterfly valve has a valve disc with a notch on said first passage side for closing said second passage and for opening said first passage to pass air through an opening formed between said notch and a wall of said first passage.

5. An engine as claimed in claim 3 or claim 4, wherein the dividing wall is relatively orthogonal with an axis of the cylinder.

6. An engine as claimed in any of claims 3 to 5, wherein:

said combustion chamber includes a first angle contained by said roof and an axis of said cylinder, and a

second angle contained by said other roof and said axis of said cylinder; and

said first angle is substantially smaller than said second angle.

7. An engine as claimed in any of claims 3 to 6, further comprising:

a hemispherical concave provided on a head of said piston so as to keep said tumble for a long time.

8. An engine as claimed in any of the preceding claims, wherein the centre line of said straight portion is approximately in parallel with a roof face of said another part of said roof.

9. A vehicle comprising a fuel injection engine as claimed in any of the preceding claims.

The Patent Office

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Application No: GB 9714736.7
Claims searched: 1 & 3

Examiner: John Twin
Date of search: 29 September 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): F1B (B2A9A)

Int Cl (Ed.6): F02B 31/00, 31/02, 31/04, 31/06, 31/08; F02F 1/42

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP 520518 A1	(Yamaha) - see eg figure 9	1 & 3
X	EP 178663 A2	(Nissan) - see eg figure 10	! & 3
A	US 5335634	(Mazda)	

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